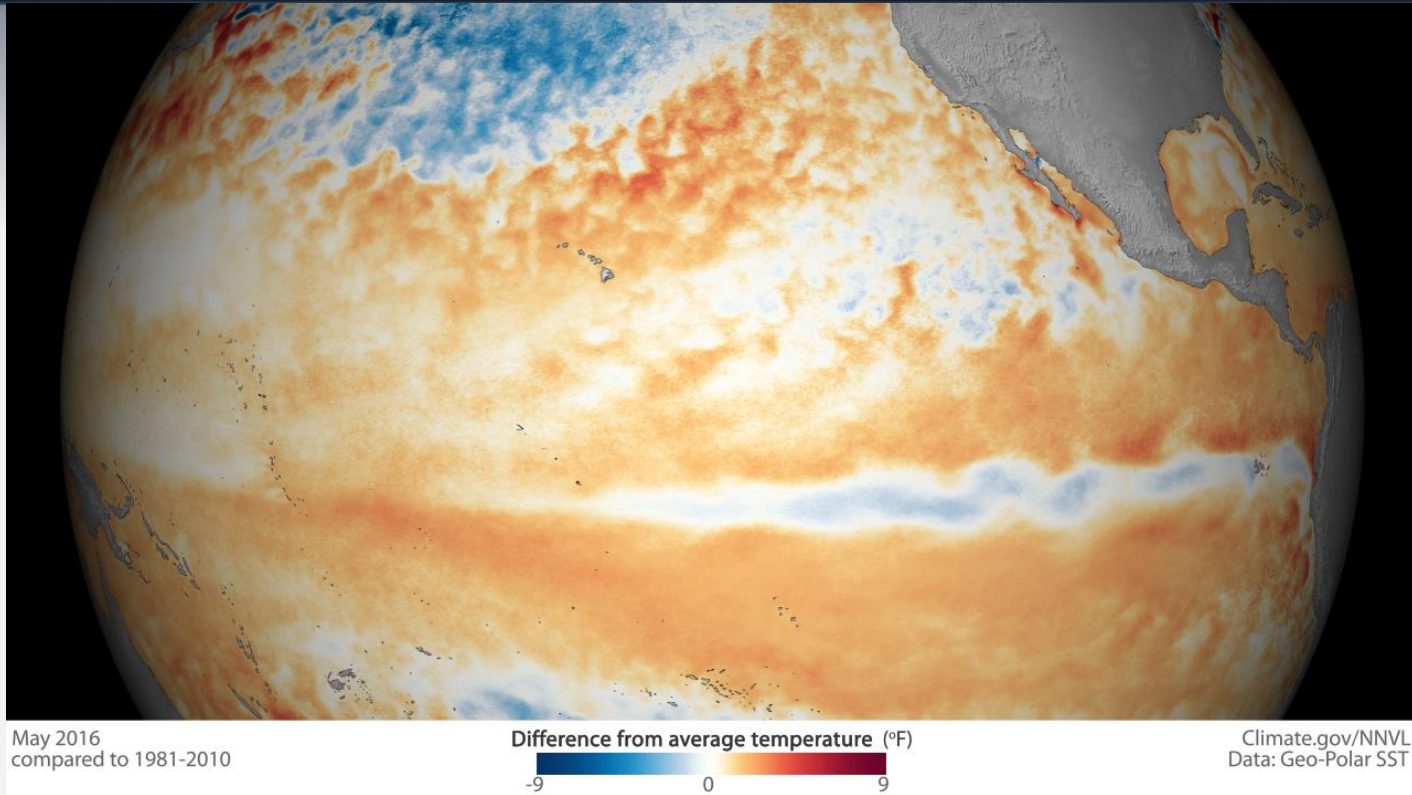




# 2016 Monsoon Outlook for Central & Northern New Mexico



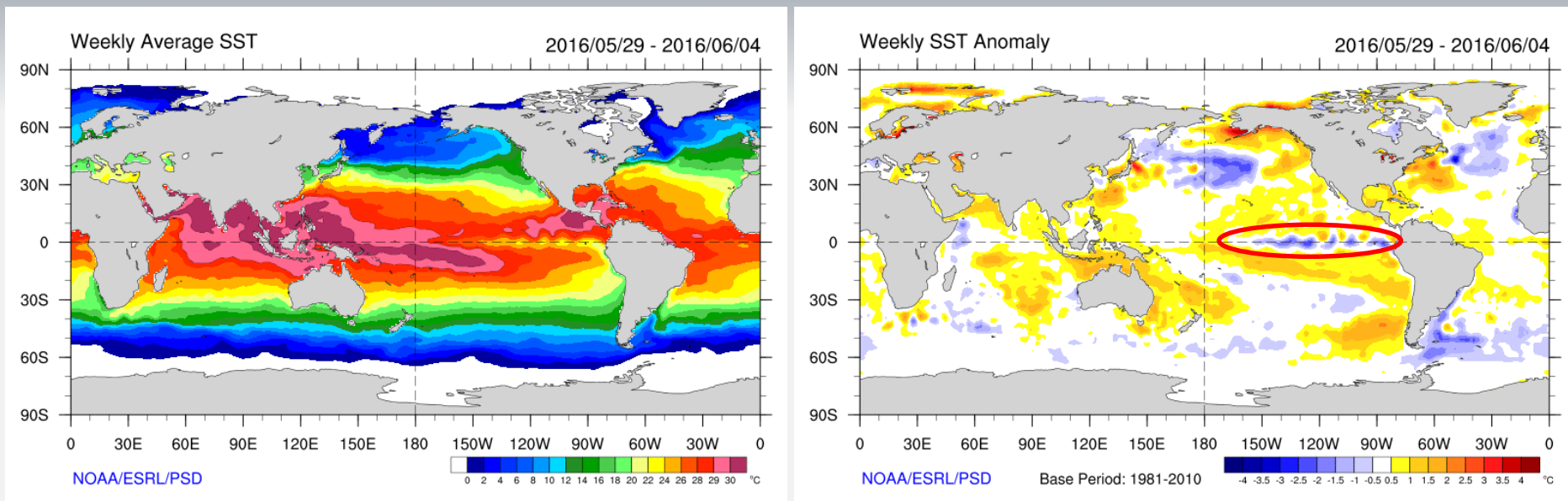
\*Updated 6/20/16  
to include latest  
IRI/CPC SSTA  
forecast (slide18).



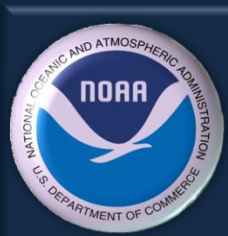
Sea surface temperatures in the Nino 3.4 region, the primary indicator for ENSO (El Niño/Southern Oscillation), have been cooling gradually since they peaked at 2.4°C (4.3°F) above average back in November 2015. How will a the transition from El Niño to a natural state and perhaps the development of La Niña by late summer, impact the North American Monsoon (NAM)?



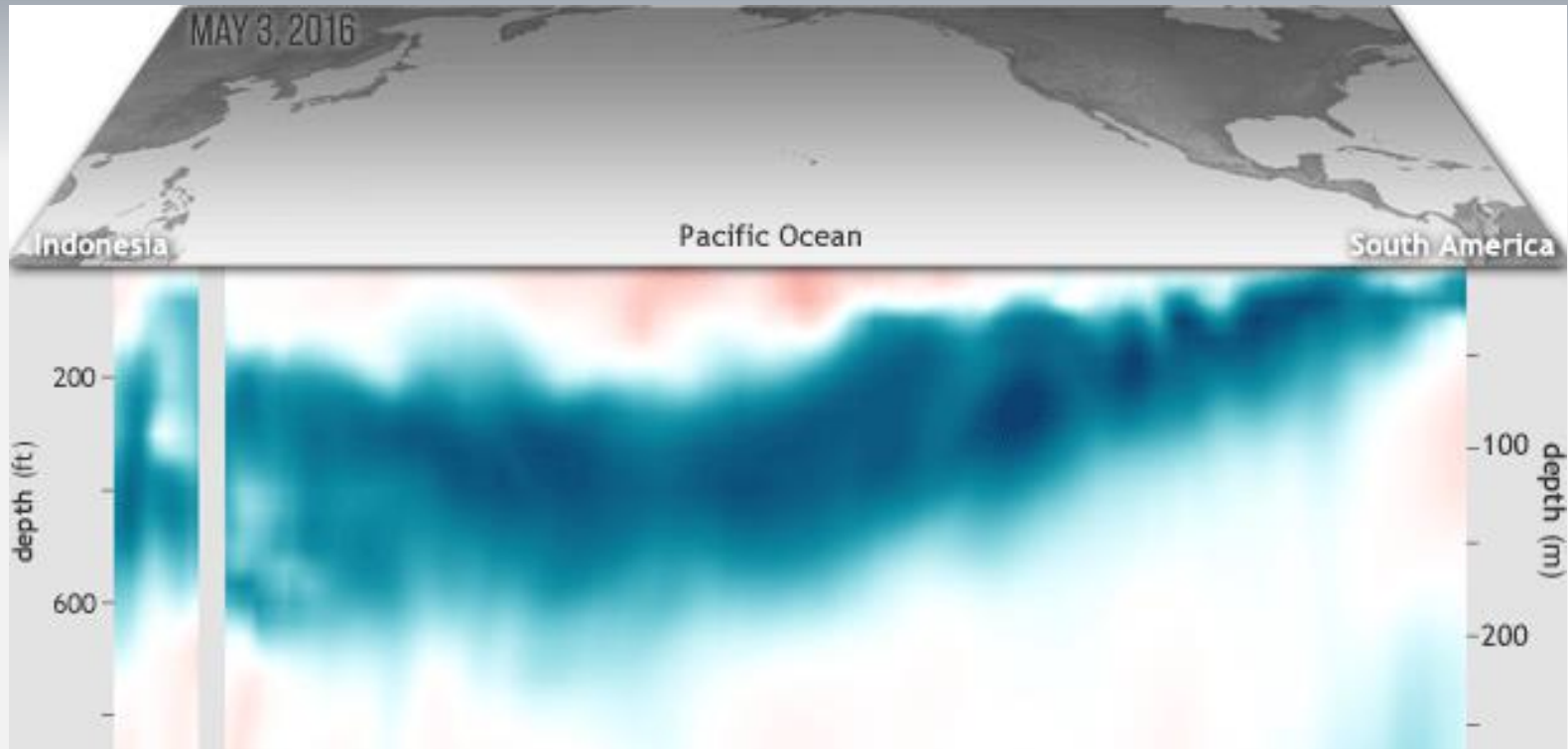
# Current State of the World's Oceans



**Figure 1 & 2.** Sea Surface Temperature (SST) and SST anomaly weekly plots showing that El Niño is done with (red oval) and the transition to either neutral or La Niña conditions is underway. Additionally, warmer than average SSTs along and near the North American coast with cooler than average SSTs in the north-central Pacific clearly show a positive Pacific Decadal Oscillation (PDO).



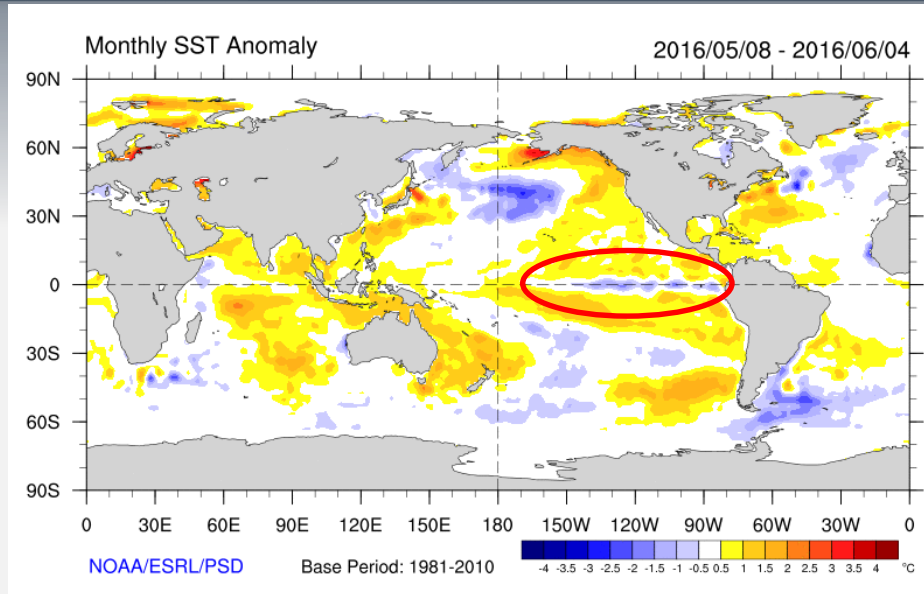
# Sub-surface Anomalies



**Figure 3.** Sub-surface water temperature anomalies continue to show below average temperatures down to approximately 200 meters (~650 feet) below the surface for much of the central and eastern Pacific Ocean.



# How Does A Fading El Niño Impact the North American Monsoon (NAM)?



**Figure 4.** SSTs from early May through early June showing El Niño is over with. A number of factors affect the strength and timing of the North American Monsoon (NAM). El Niño–Southern Oscillation (ENSO) does have an impact but it remains somewhat elusive and does not compare with stronger cool season impacts. Changes in tropical Pacific convection and temperature patterns in the Midwest are also factors that can influence the NAM. The ENSO relationship with summer precipitation in the southwestern United States is weak<sup>1</sup>. Eastern Pacific sea surface temperatures (SSTs) during a weakening El Niño are thought to encourage the ocean-land surface temperature gradient or difference needed for a strong monsoon plume to develop. Other conceptual models suggest that the land-surface temperature gradient plays a large role in Mexico and southwest Arizona but that the large scale upper level weather pattern set up (location of the Four Corners High which is mainly controlled by eastern equatorial Pacific convection) plays a bigger role for New Mexico.



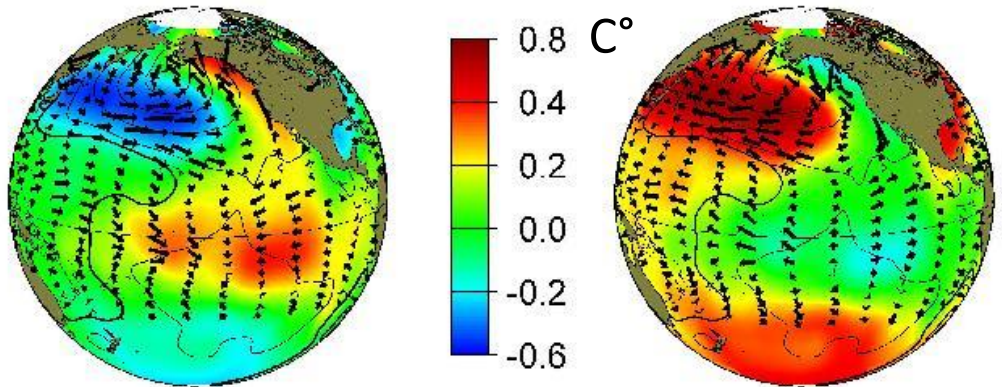
# Pacific Decadal Oscillation (PDO)



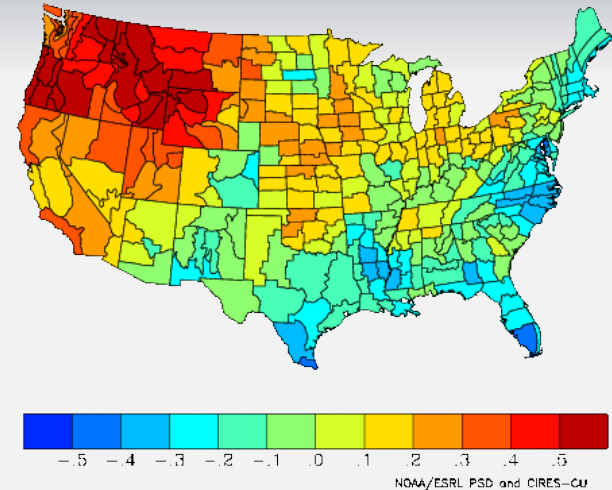
**\*April 2016 PDO index was +2.62, the highest value for the month of April since 1900.**

warm/positive phase

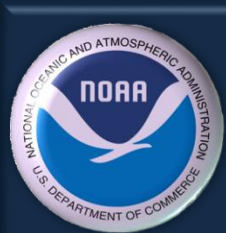
cool/negative phase



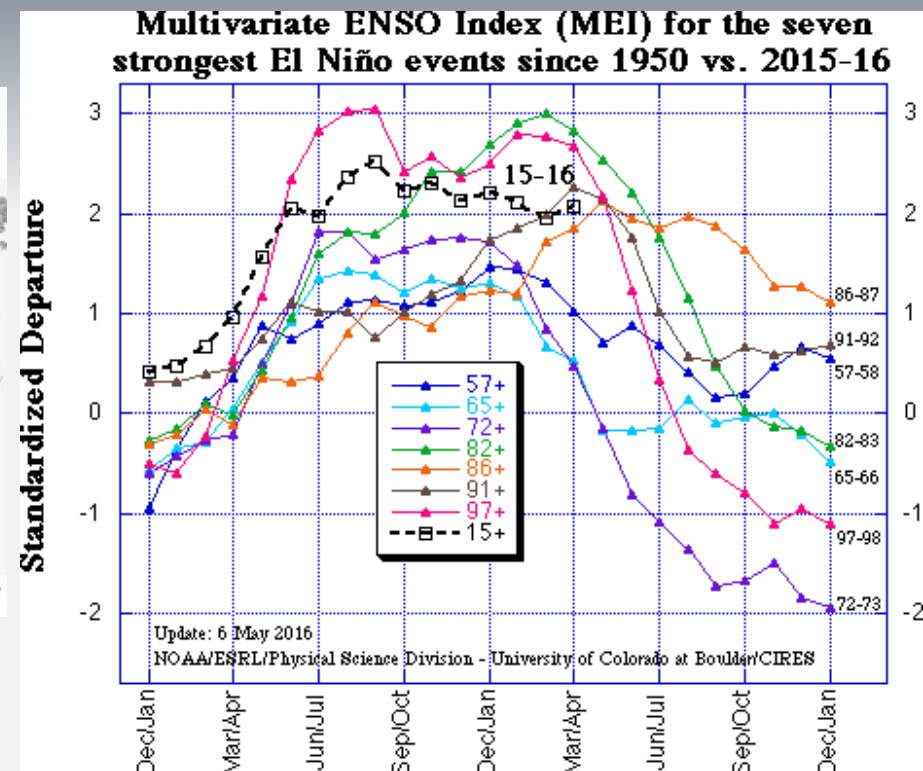
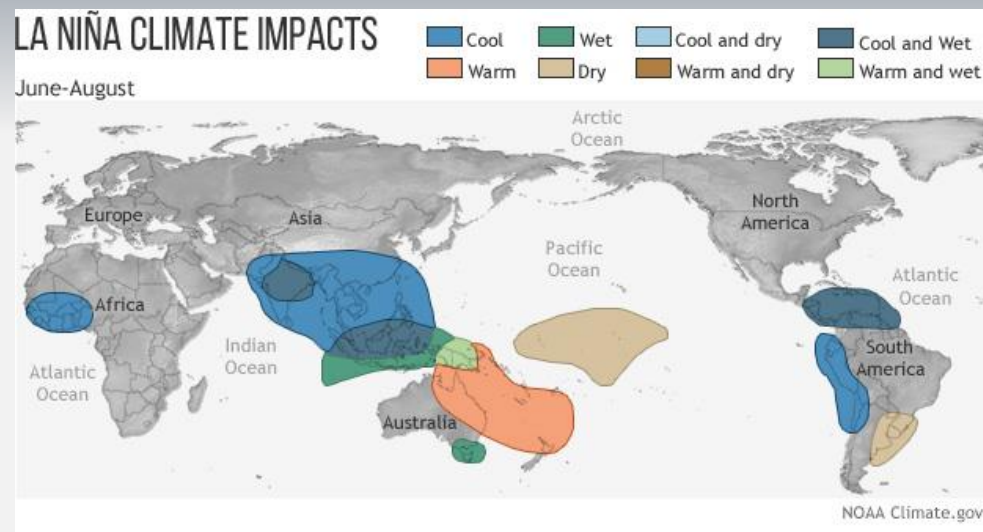
Correlation Precipitation Jul to Sep  
With Jul to Sep PDO  
1981 to 2010



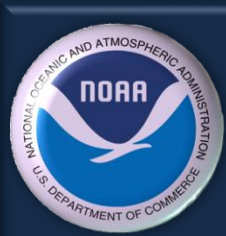
**Figure 5.** Typical wintertime Sea Surface Temperature Anomalies (colors), Sea Level Pressure (contours) and surface wind stress (arrows=force of wind on ocean surface) anomaly patterns during warm and cool phases of the Pacific Decadal Oscillation. The "Pacific Decadal Oscillation" (PDO) is a long-lived El Niño-like pattern of Pacific climate variability. Positive correlations exist during the cool season between above average precipitation and a positive/warm phase of the PDO but the correlation is negative during the North American Monsoon (NAM).



# La Niña & the NAM



**Figures 6 & 7.** Meteorological summer season climate impacts across the globe during La Niña (left). Multivariate ENSO Index (MEI) from the seven strongest El Niño events (analog years) to 2015-16 (right). Note the lack of precipitation and temperature correlations during June, July and August across North America.

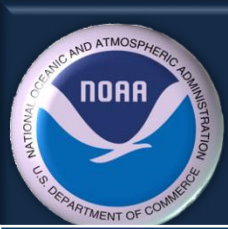


# Analog Years



YEAR	MEI MA/AM/MJ	ONI JFM/FMA/MAM	PDO M/A/M	AMO M/A/M
1973	0.48/-0.14/-0.81	1.2/0.6/0.0	-0.5/-0.69/-0.76	-0.34/-0.26/-0.16
1983	3.01/2.82/2.54	1.8/1.5/1.2	2.1/1.87/1.80	0.1/0.08/-0.03
1992	2.28/2.15/1.76	1.5/1.4/1.2	0.67/0.75/1.54	-0.79/-0.17/-0.21
1998	2.69/2.16/1.24	1.8/1.4/1.0	2.01/1.27/0.70	0.33/ 0.30/ 0.40
2016	2.07/??/??	1.9/1.6/??	2.40/2.62*/??	0.20/0.19/??

**Figure 8.** Table showing spring Multivariate ENSO Index (MEI), Oceanic Niño Index (ONI), Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Oscillation (AMO) after similar very strong El Niño events since 1950. While the AMO is listed here, correlations between the AMO and precipitation in New Mexico are higher during the cool season. April 2016 PDO index value is the highest April value on record (since 1900) and the 6<sup>th</sup> highest PDO value for any month on record.



# Precipitation Observations



Green = Above 30-yr Avg.

Brown = Below 30-yr Avg.

Site	1981-2010 avg precipitation ( July 1 - Sept. 15)	1973 (Jul 1 – Sept 15)	1983 (Jul 1 – Sept 15)	1992 (Jul 1 – Sept 15)	1998 (Jul 1 – Sept 15)
ABQ Sunport	3.58"	4.12"	1.38"	4.59"	3.25"
Santa Fe	5.12"	6.61"	4.91"	4.38"	6.12"
Clayton	6.73"	3.97"	2.03	8.44"	6.40"
Gallup	4.60"	2.79"	4.57"	5.01"	4.76"
Las Vegas	7.91"	6.63"	4.29"	6.29"	8.09"
Roswell	4.90"	6.04"	1.56"	2.74"	3.46"
Chama	6.76"	4.53"	3.62"	6.38"	9.31"
Eagle Nest	6.43"	4.42"	5.30"	2.13"	8.58"
Los Alamos	7.57"	6.69"	7.46"	8.17"	8.79"
Taos	4.35"	4.52"	5.03"	2.77"	M"
Wolf Canyon	8.29"	6.04"	8.08"	6.67"	5.90"
Carrizozo	5.51"	4.08"	2.49"	4.69"	6.15"
Luna Ranger Station	8.59"	3.23"	10.73"	6.19"	12.9"
El Morro	5.82"	4.30"	5.56"	4.79"	7.78"

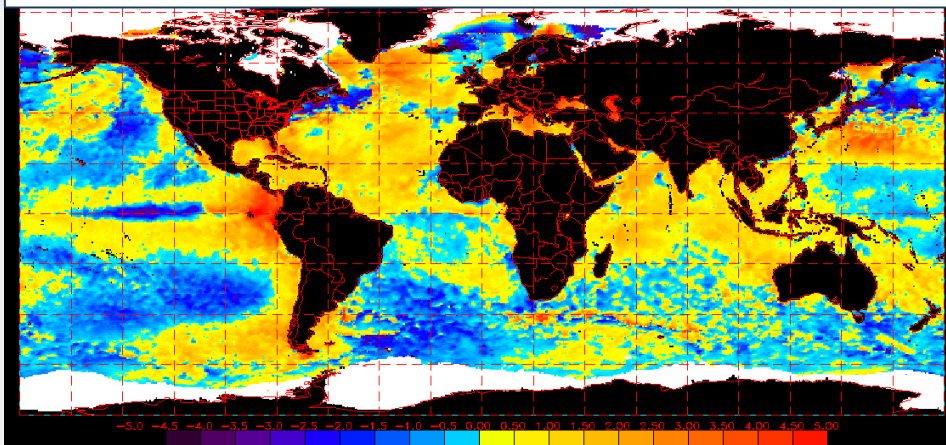
**Figure 9.** July 1 through September 15 precipitation averages (1981-2010) and analog years precipitation for select cities in central and northern New Mexico.



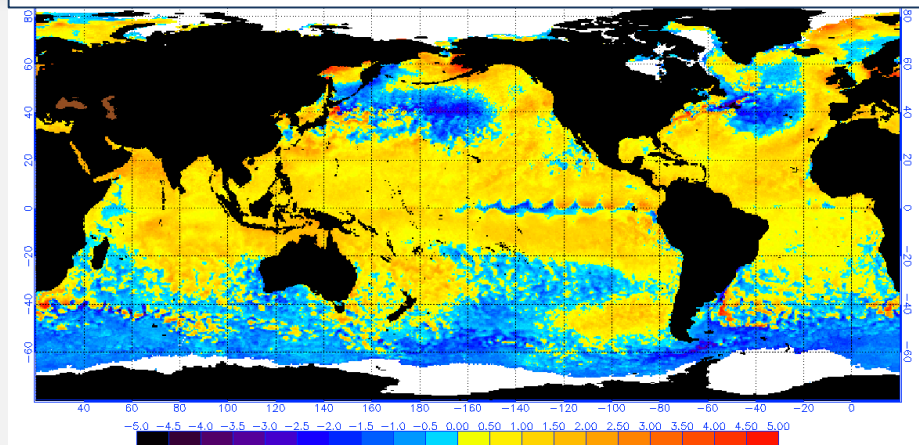
# Comparing 1998 SST Anomalies to 2016



Global SSTA's 6/9/1998



Global SSTA's 6/9/2016



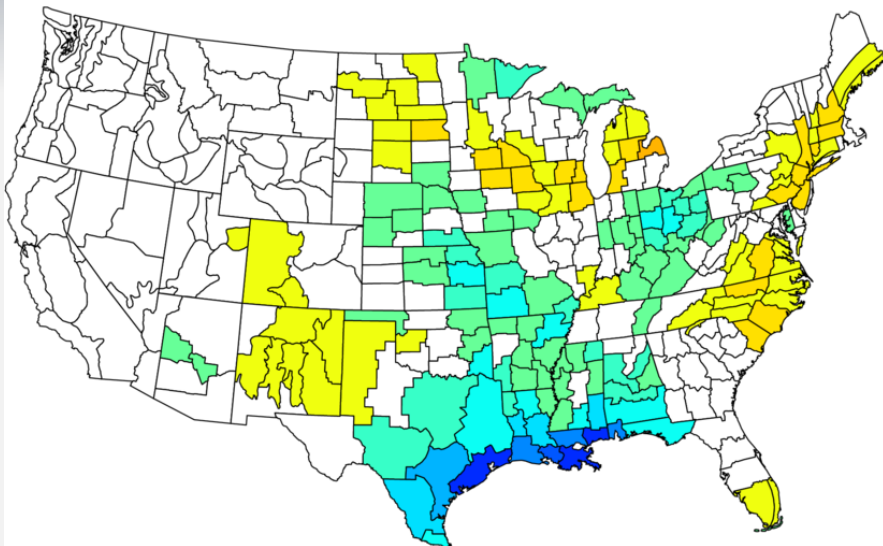
**Figures 10 & 11.** SSTAs from the closest analog year, 1998, and current conditions. Note the difference in map projection and the differences between the northeast Pacific and North Atlantic SSTA distribution.



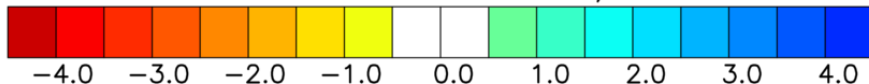
# All El Niño Years vs. Analog Years Precipitation



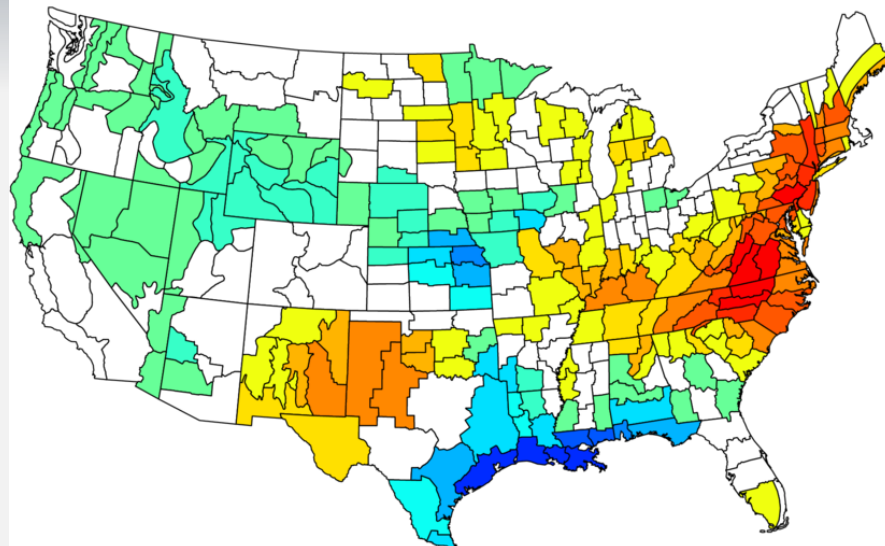
NOAA/NCDC Climate Division Composite Precipitation Anomalies (in)  
Jul to Sep 1958,1966,1973,1983,1988,1992,1998,2003,2010  
Versus 1981–2010 Longterm Average



NOAA/ESRL PSD and CIRES-CU



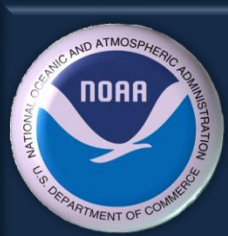
NOAA/NCDC Climate Division Composite Precipitation Anomalies (in)  
Jul to Sep 1973,1983,1992,1998  
Versus 1981–2010 Longterm Average



NOAA/ESRL PSD and CIRES-CU



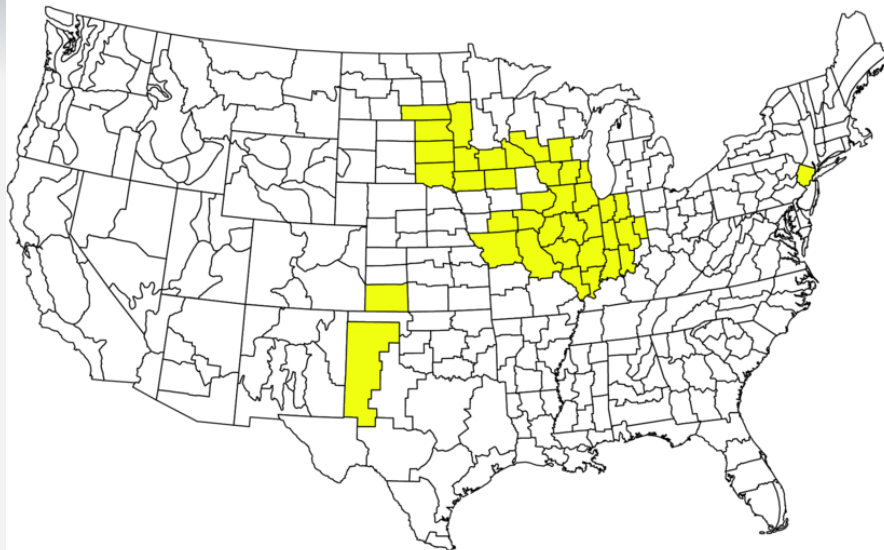
**Figure 12 & 13.** Precipitation anomalies between July and September during latter year El Niño events (left image), indicating that slightly below to average precipitation during the monsoon season was recorded. Analog years (right image) were drier with below average amounts. The borders on the map represent the Climate Prediction Center's (CPC) regional climate divisions which are defined as having similar climate conditions.



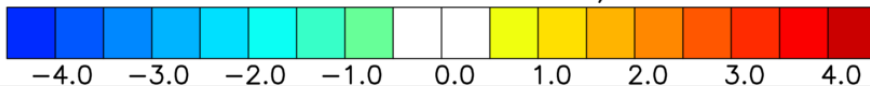
# All El Niño Years vs. Analog Years Temperature



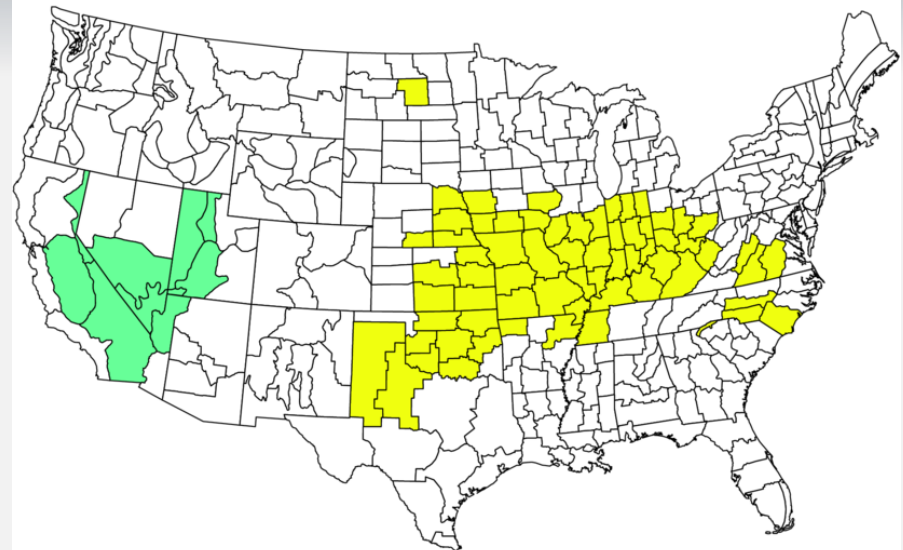
NOAA/NCDC Climate Division Composite Temperature Anomalies (F)  
Jul to Sep 1958,1966,1973,1983,1988,1992,1998,2003,2010  
Versus 1981–2010 Longterm Average



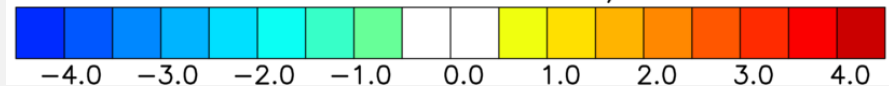
NOAA/ESRL PSD and CIRES-CU



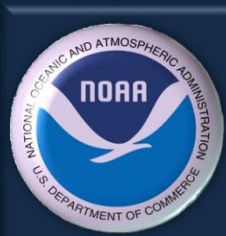
NOAA/NCDC Climate Division Composite Temperature Anomalies (F)  
Jul to Sep 1973,1983,1992,1998  
Versus 1981–2010 Longterm Average



NOAA/ESRL PSD and CIRES-CU



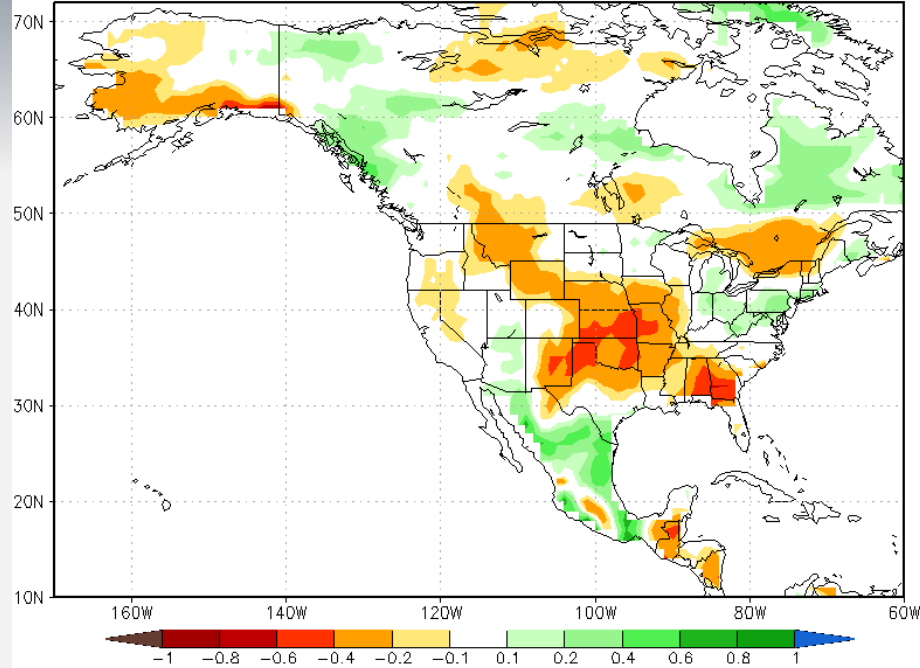
**Figures 14 & 15.** Temperature anomalies between July and September during the latter year of El Niño events (left image), indicating that average temperatures were recorded. Analog years ended up being very similar. The borders on the map represent the Climate Prediction Center's (CPC) regional climate divisions which are defined as having similar climate conditions.



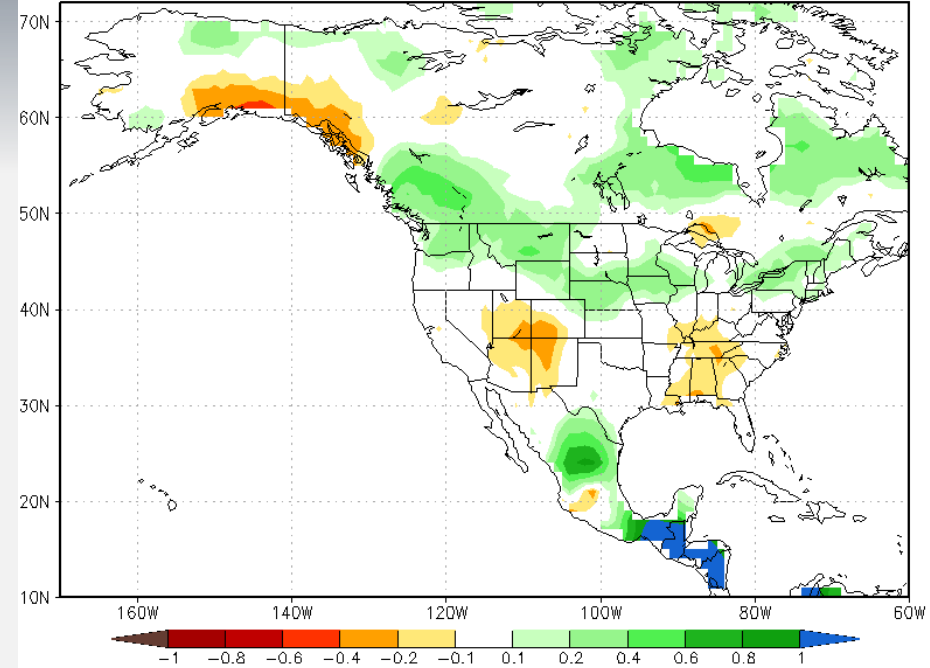
# Climate Model Forecasts



NCAR CCSM4 Forecast of Prate Anom (mm/day) IC=2016D6 for 2016JAS



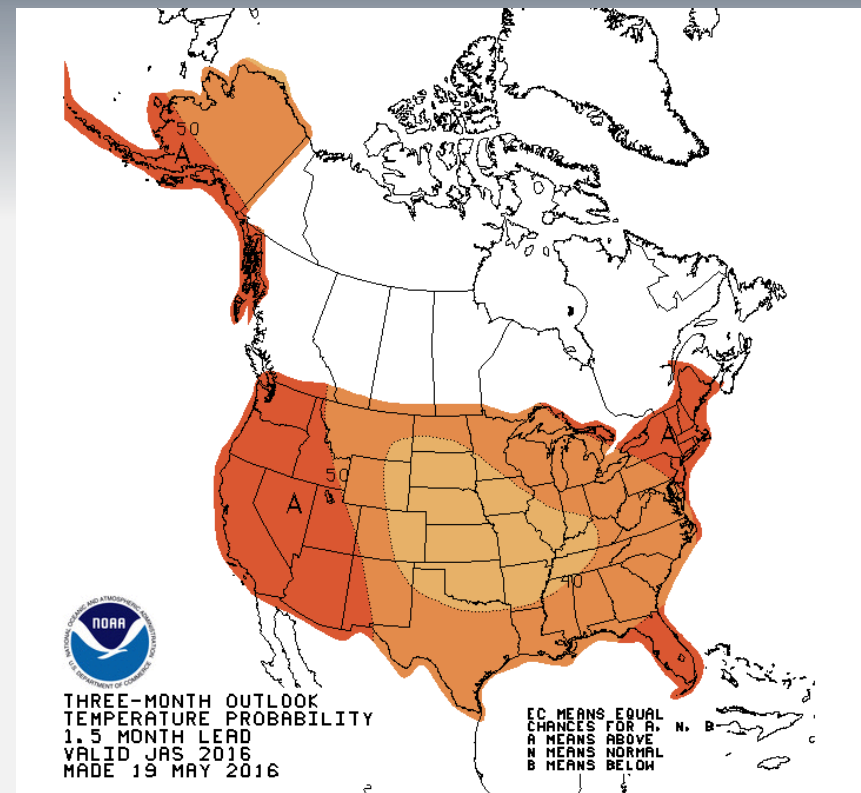
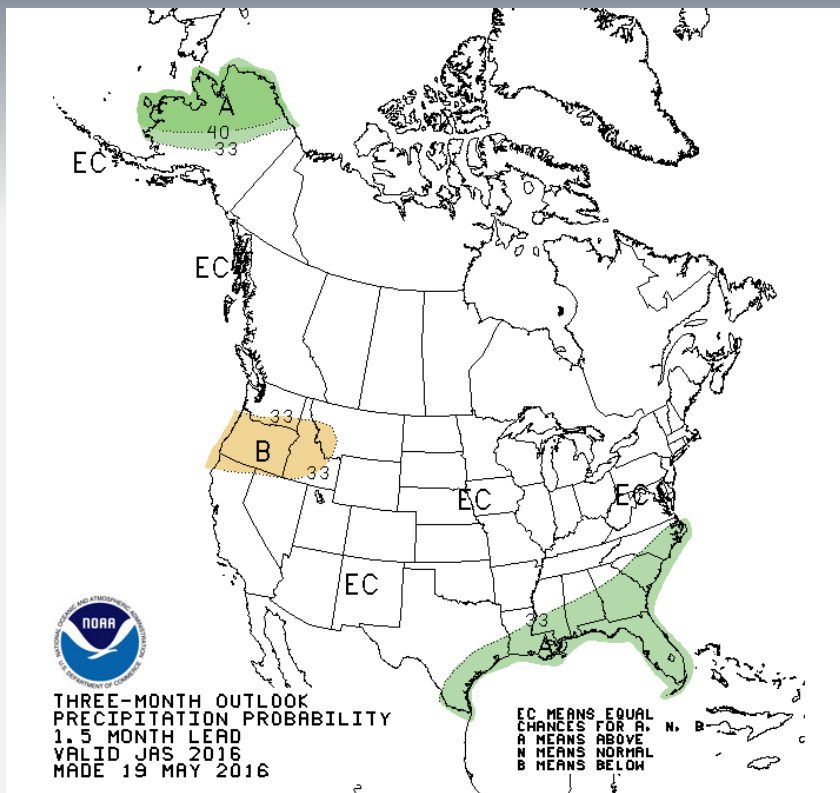
CMC1 Forecast of Prate Anom (mm/day) IC=2016D6 for 2016JAS



**Figures 16 & 17.** National Center for Atmospheric Research (NCAR) Community Climate System Model 4 (NCAR\_CCM4) and the Canadian Meteorological Model v.1 (CMC1) climate model precipitation rate forecast. These two models have the highest skill score across New Mexico for July through September. The precipitation rate forecast from the NCAR\_CCM4 for western New Mexico is near average and below average for central and eastern areas. The CMC1 model is forecasting slightly below to below average precipitation for much of central and western NM and near average east.



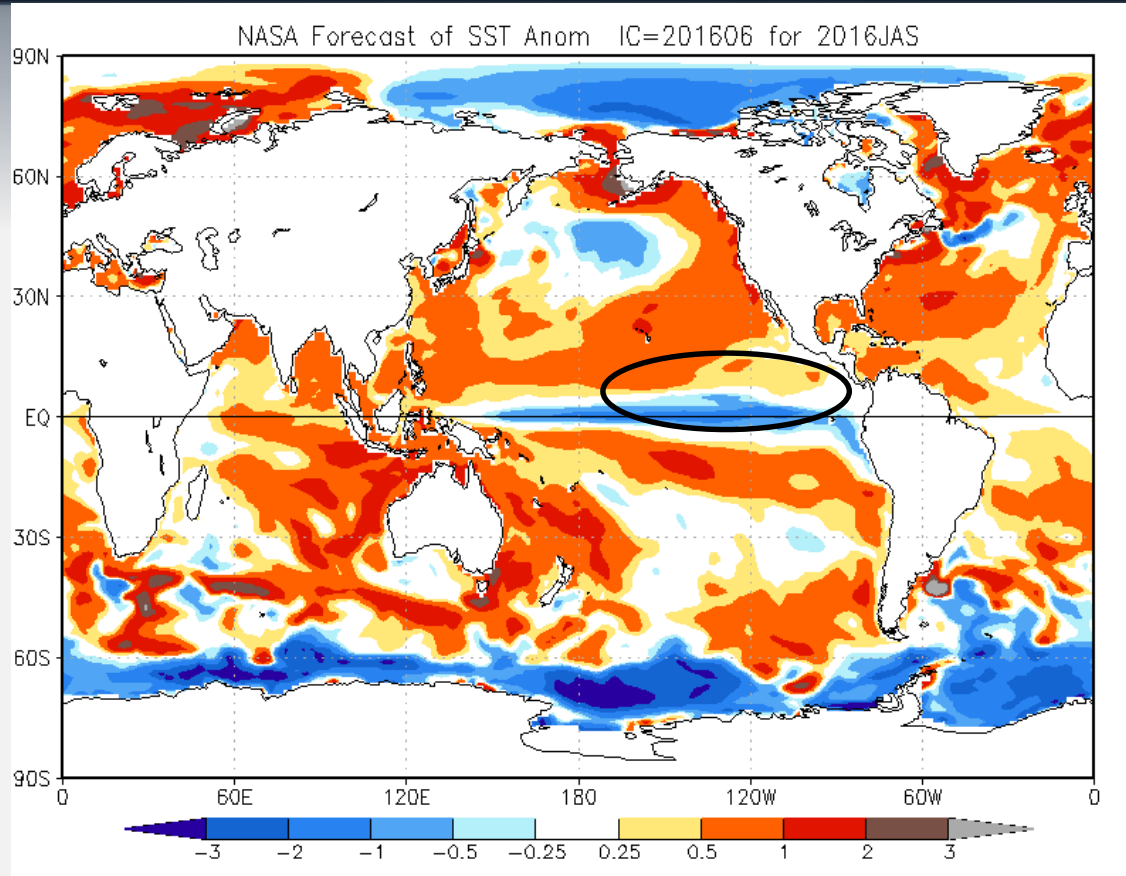
# Climate Prediction Center's July through September Outlook



**Figures 18 & 19.** CPC's July through September outlook using dynamical weather prediction models as well as climatological statistics. Equal chances are given for either above, normal/average or below average precipitation are forecast. Greater than average chances for above normal/average temperatures are forecast.



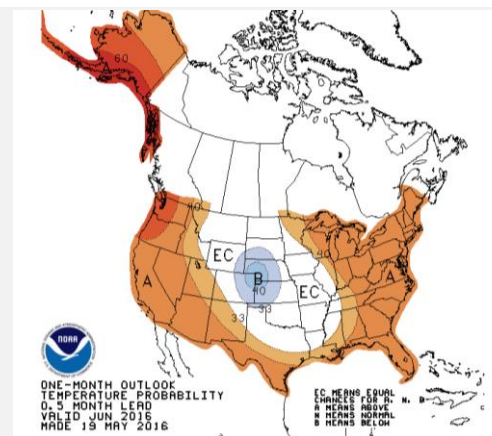
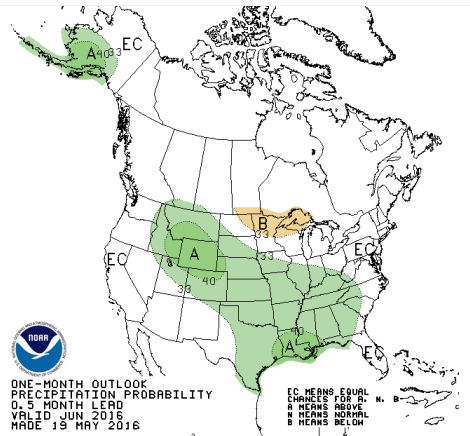
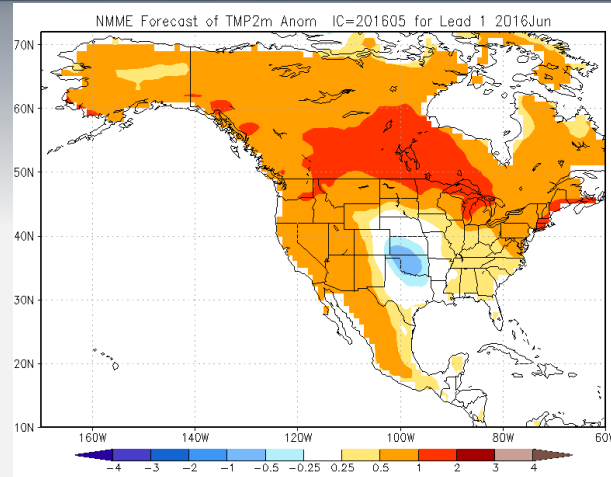
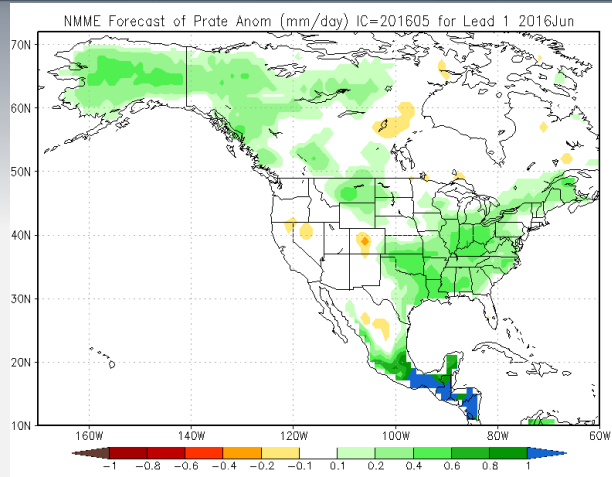
# SST Anomaly Forecast for JAS



**Figure 20.** SST Anomaly forecast from the climate model with the highest forecast skill score across the eastern Pacific Ocean, the National Aeronautics and Space Administration (NASA) model. A stronger than average SST gradient is forecast across the subtropical eastern Pacific which would lead to more deep convection than is typical in JAS. Deep convection in this part of the Pacific would strengthen the upper level trough along the west coast, forcing the four corners high eastward.



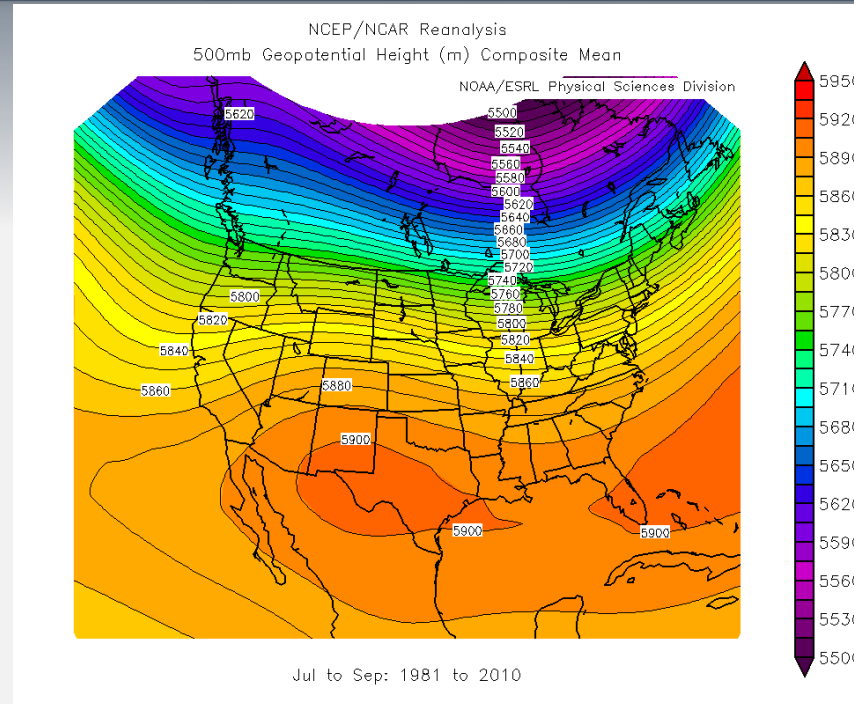
# What About the Rest of June?



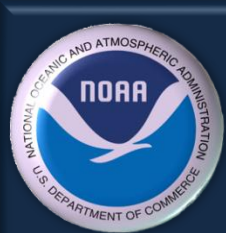
**Figures 21-24.** The climate model with the highest skill score for June in New Mexico, the NMME, is forecasting average precipitation (top left) and above average temperatures for western NM (top right). CPC's outlook is similar to the NMME (bottom images). Recent tropical convective trends across the eastern Pacific along with medium range weather perdition models would suggest above average precipitation in June for central and eastern portions of the state during June 2016. In fact, many areas across the eastern plains have already exceeded 1981-2010 precipitation averages for June.



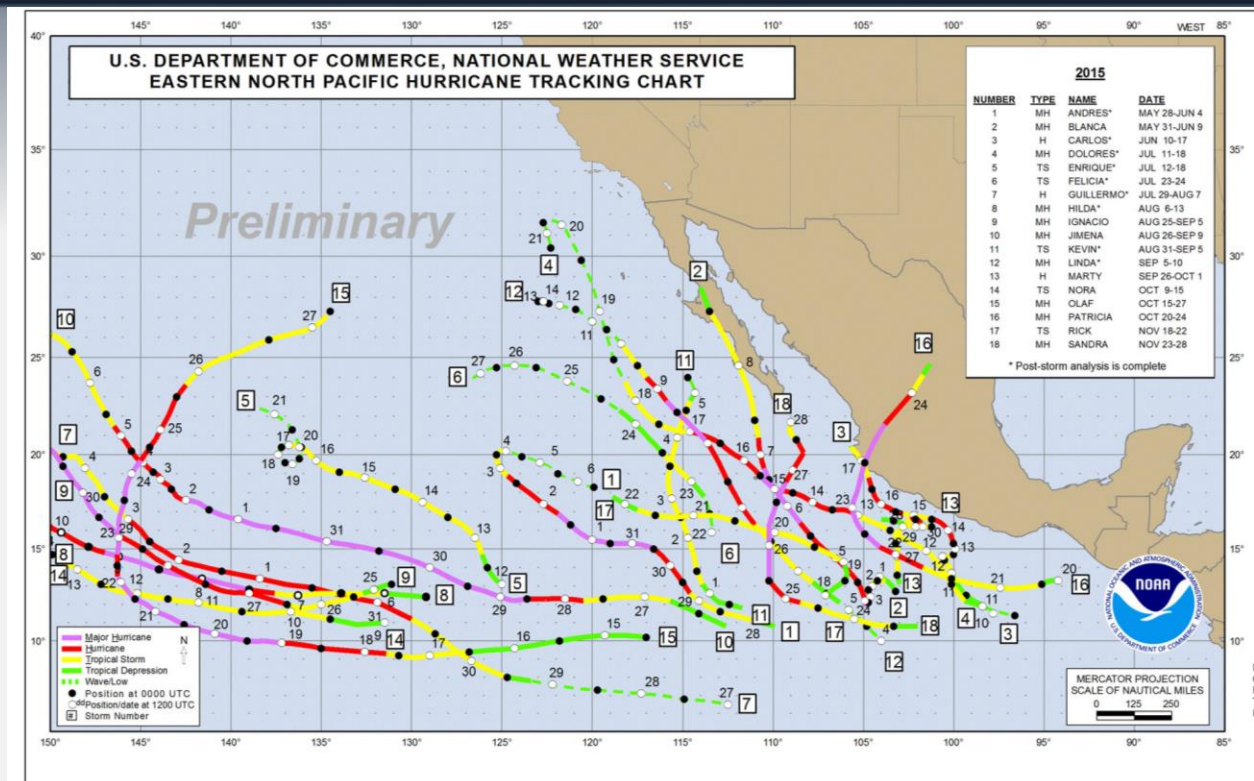
# Why Analog Years Might Not Matter Too Much in JAS 2016



**Figure 24.** Average 1981-2010 500-mb heights from July, August, and September. If there is one thing the second strongest El Niño on record taught us this past winter season is that the Pacific Ocean is not you're father's or grandfather's Pacific Ocean (slide 9). Additionally, if a strong SST gradient in the eastern equatorial Pacific continues into July, the quasi-permanent upper level trough near the west coast would end up stronger than average. This would force the "Four Corners" high farther east than average and perhaps lead to, at least temporarily, a more robust monsoonal plume over Arizona and possibly New Mexico. All hope is not lost for an above average monsoon season, particularly for western New Mexico.



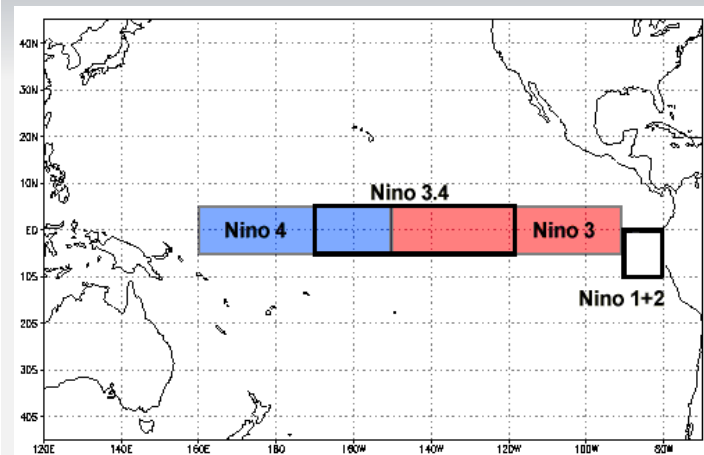
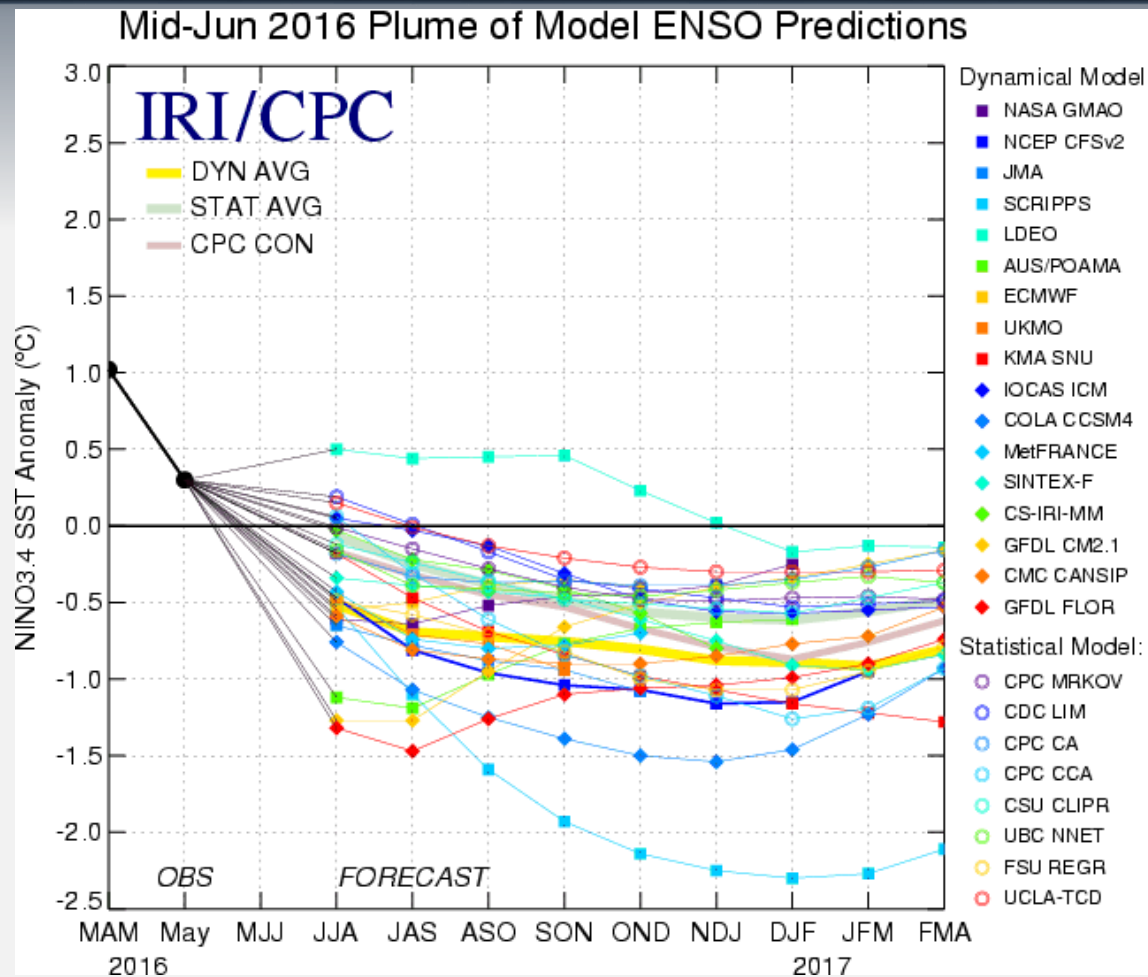
# Eastern Pacific Hurricane Outlook



**Figure 25.** 2015 Tropical cyclone track map. The eastern Pacific hurricane outlook calls for a 40 percent chance of a near-normal hurricane season, a 30 percent chance of an above-normal season and a 30 percent chance of a below-normal season. The outlook calls for a 70 percent probability of 13-20 named storms, of which 6-11 are expected to become hurricanes, including 3-6 major hurricanes. Tropical cyclone activity is surprisingly poorly correlated with JAS precipitation in NM.



# Niño 3.4 SST Anomaly Forecast

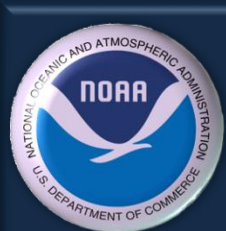


**Figure 26.** The vast majority of climate prediction models take SSTs in the eastern equatorial Pacific into La Niña territory by late summer or early fall.



# Summary

- El Niño has officially ended.
- There's a 75% chance that La Niña will be in place by the fall, meaning sea surface temperatures in the central and eastern Pacific Ocean at and near the equator will be more than  $0.5^{\circ}\text{C}$  below average. It's possible the changeover from El Niño to La Niña will be rapid, with forecasts slightly favoring La Niña developing as early as late summer.
- A rapid changeover to La Niña has the potential to result in better chances for above average precipitation in NM during the monsoon season. The upwelling of cooler than average water along and near the equator leads to stronger than usual SST gradients and above average tropical convection across the eastern Pacific Ocean. This convection normally results in a stronger than typical upper level trough near the west coast which forces the subtropical "four corners high" farther east more often than average. If the four corners high ends up farther east more often than average, deep southerly moisture surges are more likely across the southwest United States. Whether or not the deep moisture surges will impact Arizona or New Mexico or portions of both states remains elusive.

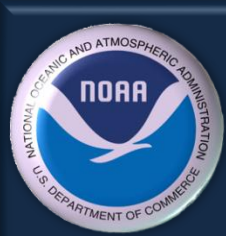


# Outlook



Cumulonimbus clouds over southwest ABQ - August 20, 2013.  
Courtesy: Todd Shoemaker.

- Based primarily on current SST observations and forecasts along with coupled atmospheric-oceanic numerical climate prediction models and a highly positive PDO, the precipitation outlook for the 2016 Monsoon season in central and northern New Mexico is for near 1981-2010 climatological averages. Analog years were essentially disregarded based on the fact that the not only are Pacific Ocean SST gradients unlike “analog” years but SST gradients worldwide are significantly different than previous spring seasons following a strong El Niño event. Keep in mind that climate models have yet to show much skill for predicting the all important SST gradients/differences that are vital for tropical and subtropical convective development. As May and early June 2016 have showed us once again that an active eastern equatorial Pacific Ocean equates to wetting precipitation across much of the Land of Enchantment. If the SST forecast from the NASA model is close to reality, a long-lived and deep southerly flow aloft is likely but determining where it sets up remains an elusive detail.
- With regard to temperature, near to slightly above average cloud cover and precipitation from thunderstorm activity is expected to result in temperatures near average for the monsoon season (July-September).



# Outlook Information



- Outlook provided by National Weather Service Forecast Office Albuquerque, NM.
- For further information contact Andrew Church:  
[Andrew\(dot\)Church\(at\)noaa.gov](mailto:Andrew(dot)Church(at)noaa.gov) (505)244-9150
- Citations/References for studies mentioned:

Adams, D.K. and A.C. Comrie. 1997, The North American Monsoon. Bulletin of the American Meteorological Society